From the Society for Clinical Vascular Surgery

Patient compliance limits the efforts of quality improvement initiatives on arteriovenous fistula maturation

Susanna K. Lynch, BS, Sadaf S. Ahanchi, MD, David J. Dexter, MD, Marc H. Glickman, MD, and **Jean M. Panneton, MD,** *Norfolk, Va*

Objective: **Our institutional quality-improvement (QI) initiative instituted a well-defined office follow-up schedule after arteriovenous fistula (AVF) creation, including an office visit within 30 days, fistulogram within 40 days, if indicated, and a second office visit within 55 days. In addition, a patient liaison contacted patients and dialysis units to improve follow-up. The purpose of this study was to determine the effect of the QI initiative on patient compliance and overall time to AVF permission to cannulate.**

Methods: **We performed a retrospective review of patients undergoing first-time radiocephalic, brachiocephalic, and basilic vein transposition creation before the QI initiative (pre-QI group: January to April 2012) and during the QI period (QI group: January to April 2013). Categoric data were compared using χ^2 analysis, and nominal data were compared using the Student *t*-test.**

Results: **We reviewed 198 first-time AVF creations in patients (57% male) with a mean age of 61 years. Demographics and comorbidities between the pre-QI and QI groups were similar. Compliance with the first 30-day postoperative appointment increased significantly after the QI initiative, from 48% in the pre-QI group to 65% in the QI group ($P = .015$). Yet, the QI initiative did not maintain an effect on the subsequent follow-up checkpoints. No statistical difference was identified for compliance with fistulogram within 40 days of access creation (pre-QI, 12% vs QI, 25%; $P = .093$) or for compliance with the 55-day postoperative appointment (pre-QI, 33% vs QI, 23%; $P = .457$). Both checkpoints demonstrated a very high noncompliance rate. Accordingly, the mean time to permission to cannulate was 88 days for both the pre-QI and QI groups, with a failure to mature rate of 22% for the pre-QI group and 21% for the QI group ($P = .816$).**

Conclusions: **The QI initiative significantly increased the number of patients complying with the first 30-day follow-up appointment after AVF access creation. However, patient compliance with a timely fistulogram and the second follow-up appointment was poor and not influenced by the QI initiative, limiting the functional effect of the QI initiative on the time to AVF permission to cannulate. (J Vasc Surg 2015;61:184-91.)**

Arteriovenous fistulas (AVFs) are considered the gold standard access for hemodialysis (HD) due to the decreased risk of complications from infection and thrombosis, longer patency, and lower cost compared with AV grafts (AVG) or tunneled dialysis catheters (TDCs).[1,2] Since its inception in 2003, the Fistula First Breakthrough Initiative (FFBI) stressed the importance of increasing AVF use by setting a AVF prevalence goal rate of 66% by 2009.[3] Although AVF placement has increased in the years after the FFBI, use of AVFs in patients has plateaued, and patients initiating HD therapy via a TDC remains as high as 80% in some areas.[4]

In addition to other AVF patient outcomes, decreasing AVF time to maturation and cannulation and failure to mature rates remains a daunting task. Debate continues throughout the literature over the best predictors of AVF maturation and methods of increasing AVF maturation and usage, and several expert panels have concluded that only very low-quality data are guiding clinical HD access placement. This is demonstrated by the lack of large randomized controlled trials.[5,6] The Kidney Disease Outcomes and Quality Initiative (KDOQI) and FFBI have encouraged the use of formalized care pathways and patient database management systems to meet the goals set by FFBI. End-stage renal disease (ESRD) networks are expected to identify beneficial changes in protocol to promote best clinical practices and use data-reporting systems to enable monitoring of patient outcomes and complications.[1,3]

In 2008, our institution reported prolonged maturation times, averaging 146 days for radiocephalic (RC) AVFs and brachiocephalic (BC) AVFs, and a high failure to mature rate of 37%.[7] To address these shortcomings, a quality improvement (QI) initiative was established in January 2013 that included a standardized protocol of preoperative dialysis duplex ultrasound imaging and follow-up schedule and a patient liaison to contact patient and dialysis units to ensure follow-up.

Preoperative dialysis duplex ultrasound scans and fistula maturation duplex ultrasound imaging were already a standard part of our group's practice but without a formal,

From the Division of Vascular Surgery, Eastern Virginia Medical School.
Author conflict of interest: none.
Presented at the Forty-second Annual Symposium of the Society for Clinical Vascular Surgery, Carlsbad, Calif, March 18-22, 2014.
Reprint requests: Sadaf S. Ahanchi, MD, Eastern Virginia Medical School, Division of Vascular Surgery, 600 Gresham Dr, Ste 8620, Norfolk, VA 23507 (e-mail: ahanchi@yahoo.com).
The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.
0741-5214

http://dx.doi.org/10.1016/j.jvs.2014.05.095

Type of Access					
Radiocephalic		Brachiocephalic	Transposed Basilic		Synthetic
Area	Location	Depth	Diameter	Velocity	Volume Flow
1	Inflow Artery			cm/sec	ml/min
2	Arterial/Proximal Anastomosis			cm/sec	
3	Distal (humeral/forearm)	mm	mm	cm/sec	ml/min
4	Mid (humeral/forearm)	mm	mm	cm/sec	
5	Proximal (humeral/forearm)	mm	mm	cm/sec	ml/min
6	Venous Confluence/ Distal Anastomosis			cm/sec	
7	Venous outflow			cm/sec	

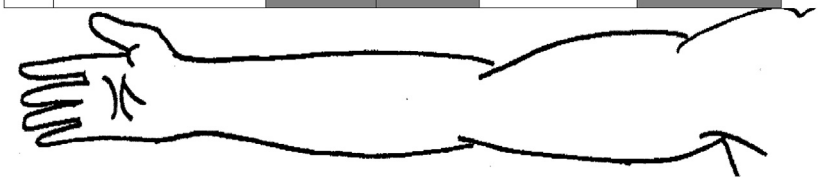

Fig 1. Sample form shows parameters measured during a fistula maturation duplex ultrasound assessment.

consistent, or enforced timeline. The preoperative dialysis duplex ultrasound assessment provides superficial vein measurements (cephalic and basilic) at eight points along the arm, including diameter and depth, as well as an arterial analysis of the location of the brachial bifurcation with brachial, radial, and ulnar artery velocities. The fistula maturation duplex ultrasound assessment measures access vein depth at three points, diameter at three points, velocity at seven points, and volume flow at three points throughout the access (Fig 1 shows a sample form). Both elements were formally incorporated into the mandated follow-up schedule, which was enforced by the patient liaison during the QI period.

METHODS

After obtaining approval from the Eastern Virginia Medical School Institutional Review Board, we used the Current Procedural Terminology (American Medical Association, Chicago, Ill) codes 36818, 36819, 36820, 36821, 36825, and 36830 to query the practice's billing database and generate a list of patients who underwent AV access surgery between January 1, 2012, and April 12, 2013. Patient consent was waived for this minimal risk study and in compliance with the Health Insurance Portability and Accountability Act. Only first-time AVF placements were included in the review; patients who had undergone previous AV access surgery or received an AVG were excluded. Also excluded were patients within the interim implementation and training period for the QI (October to December 2012). Patients with a temporary or TDC were not excluded.

Office and hospital records were reviewed for patient demographics, pertinent medical history, physical examination findings, preoperative and postoperative duplex imaging, and postoperative follow-up. Operative and intervention notes were reviewed for relevant procedural findings and complications. Information was deidentified and recorded in a password-protected database (Microsoft Corp, Redmond, Wash). Two groups were compared: patients who had AVF creation before the QI initiative (pre-QI group: January to April 2012) and patients who had AVF creation during the QI period (QI group: January to April 2013).

The QI initiative outlined a timeline for AVF access creation (Fig 2). Previous studies have examined the different components and timing of postaccess creation follow-up, including determination of suitability for usage, duplex usage, and fistulogram usage.[1,8-13] Our protocol was developed based on a review of this literature, existing institutional protocols, and collaborative efforts between the surgeons, nursing and office staff, dialysis unit managers, and hospital management. Upon nephrologist request or within 2 weeks of TDC placement, appointments were scheduled for a preoperative dialysis duplex ultrasound assessment and a consultation with a vascular surgeon to arrange for permanent access creation. The preoperative dialysis duplex ultrasound protocol was duplex and Doppler imaging of the entire length of the cephalic and basilic veins bilaterally to assess size, depth, and patency. Waveforms, velocities, and B-mode imaging of radial and brachial arteries was also performed.

After review of the dialysis duplex ultrasound images, the vascular surgeon would schedule and perform a fistula or graft placement within 1 to 2 weeks. After the operation, the patient would undergo a fistula maturation duplex ultrasound assessment in our clinic within 2 to 3 weeks and then have an appointment with the surgeon to review AVF maturation within 4 weeks. If the fistula appeared to be maturing, the surgeon would give permission to cannulate immediately or within 1 to 2 weeks, or would follow-up in a second appointment 2 weeks later with another. Any evidence of stenosis resulted in a fistulogram and possible intervention within 10 days. The patient was then scheduled for a second follow-up appointment 2 weeks after the fistulogram or intervention, at which time the patient received permission to cannulate or underwent another intervention for maturation.

All scheduling and reminders of appointments were done through the regular office staff. The patient liaison

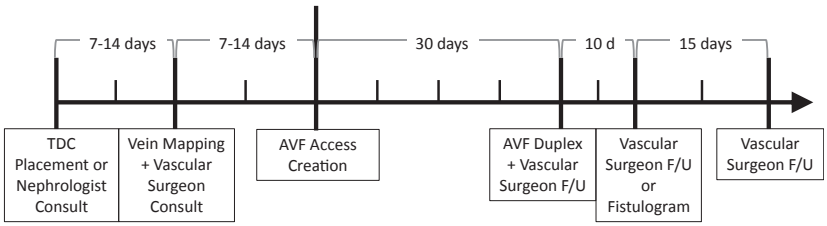

Fig 2. Timeline illustrates the standardized protocol for arteriovenous fistula (*AVF*) creation from referral to maturation. *F/U,* Follow-up; *TDC,* tunneled dialysis catheter.

hired by our group, termed the dialysis coordinator, received a list of missed office visits or duplex appointments and called the patient to schedule a new appointment. If the patient liaison could not get directly in touch with the patient after two attempts and the patient was already on HD, she called the dialysis unit to follow-up on the patient's progress. The unit coordinator, social worker, or nephrologist talked to the patient, and if the patient was willing, the appointment was rescheduled.

Primary end points were time to permission to cannulate, failure to mature, and death. Secondary end points were intervention rate, compliance with protocol follow-up appointments within 30, 40 and 55 days, and primary, primary assisted, and secondary patency. Interventions included percutaneous transluminal angioplasty, ligation, coil embolization, thrombectomy, superficialization, and distal revascularization interval ligation.

Continuously distributed data were evaluated using the independent-samples *t*-test, and categoric data were evaluated using χ^2 analysis. Kaplan-Meier curves were used to compare the patency between the pre-QI and QI cohorts. Data were analyzed using IBM SPSS 21.0 software (IBM Corp, Armonk, NY).

RESULTS

Demographics. AVFs were created in 236 patients: 123 from January 1, 2012, through April 30, 2012 (pre-QI group), and 113 from January 1, 2013, through April 12, 2013 (QI group). Patient selection is illustrated in Fig 3. The study excluded patients who died before maturation, were lost to follow-up, decided against continued care, and those in whom we were unable to assess fistula maturity by the close of the study. We excluded these patients due to inability to assess compliance. Those in whom we were unable to assess maturity by the close of the study had a future scheduled appointment past the date of the end of the study and the access has not yet been abandoned or given permission to be cannulated.

Demographics and comorbidities of the study cohort are listed in Table I. At the time of AVF creation, 68% of the pre-QI patients were undergoing HD by a temporary or TDC compared with 67% of the QI cohort ($P = .762$). The pre-QI cohort was composed of 60 men (55%), with an average age of 60 years and a mean body mass index of 31 kg/m^2, and the QI cohort was composed of 53 men (60%; $P = .422$), with an average age of 62 years ($P = .477$) and mean body mass index of 31 kg/m^2 ($P = .448$).

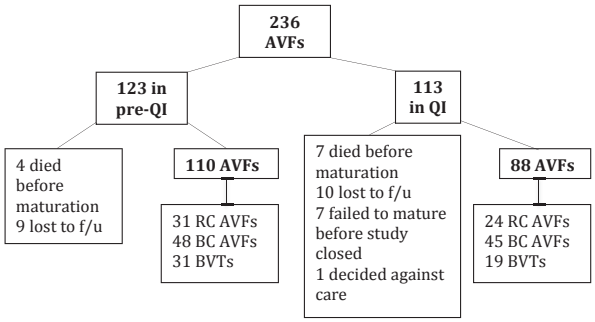

Fig 3. Flow chart shows stratification of all patients who underwent arteriovenous fistula (*AVF*) creation from January 1, 2012, through April 30, 2012 (before the quality-improvement [*pre-QI*] initiative), and from January 1, 2013, through April 12, 2013 (*QI*). Only patients who underwent first-time autologous AVF creation were included in the study. *BC,* Brachiocephalic; *BVT,* basilic vein transposition; *f/u,* follow-up; *RC,* radiocephalic.

Table I. Patient demographics and comorbidities

Variables[a]	*Pre-QI (n = 110)*	*QI (n = 88)*	P
Male	60 (55)	53 (60)	.422
Age, years	60 ± 15	62 ± 14	.477
BMI, kg/m^2	31 ± 8	31 ± 8	.448
Race			
African American	79 (72)	57 (65)	
Caucasian	26 (24)	27 (31)	
Hispanic	4 (3)	1 (1)	
Asian/Pacific Islander	1 (1)	3 (3)	
Diabetes	71 (65)	62 (71)	.448
Hypertension	108 (99)	86 (98)	.587
ESRD on HD	75 (68)	58 (66)	.762
Dyslipidemia	69 (63)	65 (74)	.126
Tobacco use	67 (62)	49 (56)	.467
CHF	40 (37)	25 (28)	.227

BMI, Body mass index; *CHF,* congestive heart failure; *ESRD on HD,* end-stage renal disease on hemodialysis; *Pre-QI,* fistula creation before the quality-improvement initiative was instituted; *QI,* fistula creation after quality-improvement initiative was instituted.

[a]Categoric data are shown as number (%) and continuous data as mean ± standard deviation.

Preoperative and operative data. Of the 198 patients included in the study cohort, 110 initial AVF accesses were created during the pre-QI period: 31 RC (28%), 48 BC

Table II. Overall compliance and patient-related outcomes

Variable[a]	*Pre-QI*	*QI*	P
Compliance with 1st appointment	53 (48)	55 (65)	.029
Average days to 1st appointment	40.8 ± 43.4	33.2 ± 18.3	.099
Compliance with fistulogram	2 (12)	11 (33)	.173
Average days to fistulogram	66 ± 34	57 ± 29	.324
Compliance with 2nd appointment	18 (25)	15 (23)	.842
Average days to 2nd appointment	77 ± 27	77 ± 28	.907
Time to maturation, days	88 ± 46	88 ± 47	.920
Failure to mature	24 (22)	18 (21)	.862
Mean number of interventions	0.42	0.61	.116
Mortality	6 (6)	4 (5)	.772

Pre-QI, Fistula creation before the quality-improvement initiative was instituted; *QI,* fistula creation after quality-improvement initiative was instituted.
[a]Categoric data are shown as number (%) and continuous data as mean ± standard deviation.

Table III. Mean interventions per access by arteriovenous fistula (*AVF*) location, as indicated for maturation

Variable	*Pre-QI*	*QI*	P-*value*
RC AVF			
PTA	0.61	0.48	.402
Thrombectomies	0.03	0.00	.325
Surgical revisions	0.03	0.00	.325
Branch ligations	0.00	0.09	.249
Coil embolizations	0.23	0.04	.044
Superficializations	0.07	0.04	.738
BC AVF			
PTA	0.38	0.63	.139
Thrombectomies	0.04	0.00	.165
Branch ligations	0.00	0.02	.310
Coil embolizations	0.13	0.20	.357
Superficializations	0.00	0.04	.147
DRILs	0.04	0.02	.585
BVT			
PTA	0.26	0.58	.051
Thrombectomies	0.07	0.00	.268
DRILs	0.00	0.05	.205

BC, Brachiocephalic; *BVT,* basilic vein transposition; *DRIL,* distal revascularization-interval ligation; *Pre-QI,* fistula creation before the quality-improvement initiative was instituted; *PTA,* percutaneous transluminal angioplasty; *QI,* fistula creation after quality-improvement initiative was instituted; *RC,* radiocephalic.

(44%), and 31 BVT (28%). During the QI period, 88 initial AVF accesses were created: 24 RC (27%), 45 BC (51%), and 19 (22%) BVT ($\chi^2 = .487$). Within the pre-QI cohort, the mean vein size at the site of access creation on preoperative ultrasound imaging was 2.79 mm in RC AVFs, 3.19 mm in BC AVFs, and 3.28 mm in BVTs at mean depths of 2.74 mm for RC AVFs and 3.51 mm for BC AVFs. Within the QI cohort (compared with the pre-QI cohort), the mean vein size was 2.91 mm in RC AVFs ($P = .670$), 3.88 mm in BC AVFs ($P = .017$), and 3.23 mm in BVTs ($P = .912$) at mean depths of 3.10 mm ($P = .537$) and 3.36 mm ($P = .695$), respectively. No statistical difference was seen in the percentage of male patients in the pre-QI vs the QI group for any AVFs, averaging 78% men for RC AVFs, 46% men for BC AVFs, and 54% men for BVTs.

Patient compliance. All pre-QI follow-up appointment scheduling was left to the surgeon's discretion, whereas follow-up appointments in the QI period were scheduled according to the protocol timeline. Compliance with the first postoperative appointment was defined as attending the appointment within 30 days of the operation. In the pre-QI cohort, 53 patients (48%) attended the first appointment within 30 days; the average number of days to the first appointment was 41 ± 43 days. In the QI cohort, 55 patients (65%) attended the first appointment within 30 days ($P = .029$); the average number of days to the first appointment was 33 ± 18 days ($P = .099$). According to our protocol, the next mandated visit was a fistulogram within 40 days if indicated. Only two patients (12%) from the pre-QI cohort underwent a fistulogram within 40 days, with an average number of days from AVF creation of 66 ± 34 days. In comparison, 11 patients (33%) from the QI cohort attended within 40 days ($P = .173$), with an average time of 57 ± 29 days ($P = .324$).

The second appointment attendance was assessed as within 55 days of AVF creation. Of the pre-QI cohort, 18 patients (25%) attended within 55 days, with the average time to attendance of 77 ± 27 days. Of the QI cohort, 15 patients (23%) attended within 55 days ($P = .842$), with the average time to attendance of 77 ± 28 days ($P = .907$). Comparison of compliance and notable patient outcomes are presented in Table II.

Patient-related outcomes. The average time to permission to cannulate was 88 ± 46 days in the pre-QI cohort and 88 ± 47 days ($P = .920$) in the QI cohort; only two pre-QI and three QI patients had permission to cannulate before 4 weeks. When broken down by access location, permission to cannulate for pre-QI vs QI patients was 83 ± 46 vs 100 ± 47 days ($P = .285$) for RC AVFs, 73 ± 39 vs 75 ± 41 days ($P = .872$) for BC AVFs, and 116 ± 43 vs 111 ± 50 days ($P = .725$) for BVTs.

In the pre-QI cohort, 24 AVFs failed, making the failure to mature rate 22% compared with 18 failed AVFs in the QI cohort, resulting in a failure rate of 21% ($P = .862$). Failure rates by location in pre-QI vs QI were 19% vs 46% for RC AVFs ($P = .044$), 21% vs 11% for BC AVFs ($P = .264$), and 26% vs 11% for BVTs ($P = .282$). The mean number of interventions after AVF creation per access was 0.42 and 0.61 for the pre-QI and QI groups, respectively ($P = .116$). By access location, the mean number of interventions per access in the pre-QI vs QI group was 0.58 vs 0.57 in the RC AVFs ($P = .941$), 0.42 vs 0.65 in the BC AVFs ($P = .246$), and 0.26 vs 0.58 in the BVTs ($P = .091$). Table III presents intervention data broken down by AVF location. The number of days between BVT creation and transposition

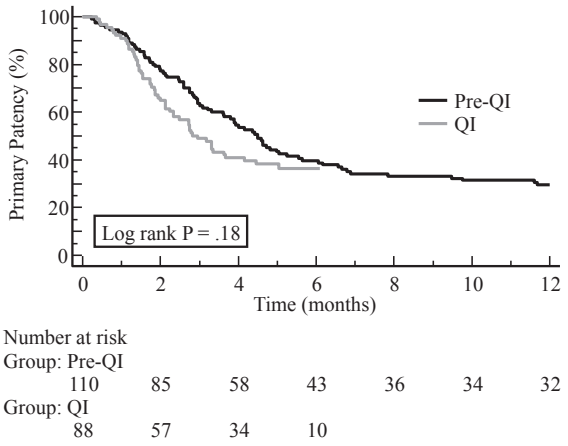

Fig 4. Kaplan-Meier survival curve depicts loss of primary patency in patients who underwent arteriovenous fistula (AVF) creation from January 1, 2012, through April 30, 2012 (before the quality-improvement [*pre-QI*] initiative), and from January 1, 2013, through April 12, 2013 (*QI*). Standard error of the mean <10% for all time points.

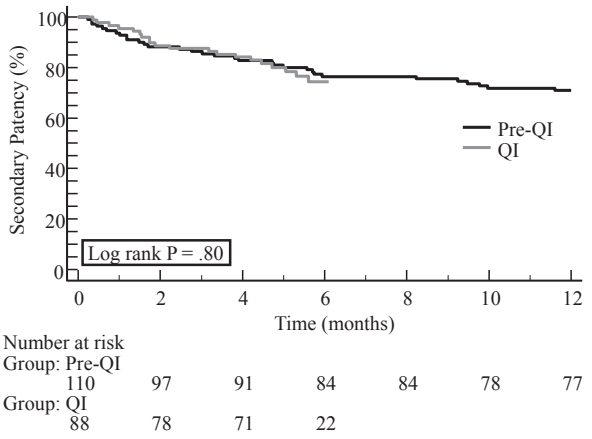

Fig 5. Kaplan-Meier survival curve depicts loss of secondary patency in patients who underwent arteriovenous fistula (*AVF*) creation from January 1, 2012, through April 30, 2012 (before the quality-improvement [*pre-QI*] initiative), and from January 1, 2013, through April 12, 2013 (*QI*). Standard error of the mean <10% for all time points.

was 67 ± 31 days in the pre-QI cohort compared with 56 ± 27 days in the QI cohort ($P = .204$).

Kaplan-Meier survival curves of primary and secondary patency illustrate no statistical difference between the pre-QI and QI cohorts (Figs 4 and 5). Although primary patency was lost slightly earlier in the QI cohort, the 6-month end points and secondary patency end points were not different. At 6 months, primary patency was 38.8% in the pre-QI group and 36.3% in the QI group and secondary patency was 76.4% in the pre-QI group and 74.4% in the QI group.

DISCUSSION

To meet the KDOQI guidelines and FFBI goals, vascular surgeons, nephrologists, and ESRD networks across the United States have made a concerted effort to increase AVF creation and use to decrease morbidity and mortality associated with ESRD and improve patient quality of life. Furthermore, future health care measures and reimbursement will incorporate HD access type utilization to assess dialysis units, creating a financial incentive to ensure the highest proportion of functional AVF usage.[14,15] Although the initial increase in AVF creation did increase the percentage of HD patients in the United States using an AVF as their primary vascular access, that number has plateaued in recent years.[16]

Our group previously determined our AVF time to maturation was much longer than the optimal 4- to 6-week maturation time quoted in the literature. Historically, our failure to mature rate of 20% was similar to other studies, but our primary patency rates were lower than those reported in the literature.[7] The QI initiative attempted to improve these outcomes and the time to permission to cannulate by using a standardized protocol outlining a follow-up schedule and hiring a patient liaison to follow-up with patients and communicate with dialysis units. Development of the protocol incorporated a literature review, current institutional protocols and those from other ESRD networks, as well as collaboration between vascular surgeons, office and hospital management, and dialysis unit managers to create an integrated, effective follow-up protocol along KDOQI guidelines.

Although our time to permission to cannulate improved compared with our historical time of 146 days, the difference between the pre-QI and QI cohorts was not statistically significant. The improvement from the 2005 data we have previously published likely reflects the effect of incorporating electronic medical records to schedule and monitor patients and the more frequent use of preoperative and postoperative duplex scanning. These practice procedures were the same in the pre-QI and QI cohorts. Our failure to mature and mortality rates were also the same between the two study cohorts. The pre-QI and QI cohorts had similar rates for AVF location, but outcomes varied within those categories. BC AVFs demonstrated the best outcomes overall in the QI cohort in time to permission to cannulate and failure to mature, which may be accounted for by the significantly larger preoperative vein size. The only parameters that are widely supported in the literature as significant predictors of AVF maturation or failure are size of the vein preoperatively and the surgeon's expertise.[17] Our findings regarding vein size confirm this conclusion. The effect of surgeon expertise on any differences between the pre-QI and the QI group were negligible because the same group of surgeons performed the surgeries during both time periods.

The lack of improvement in AVF time to permission to cannulate and failure rates demonstrates poor overall AVF outcomes in our patient population. In addition, we were unable to assess whether the poor outcomes could have

been improved by our efforts to ensure prompt permission to cannulate or intervention for stenosis because a substantial number of patients were not compliant with the protocol.

Patient compliance has been recognized as a significant factor affecting patient outcomes in ESRD and HD. Kutner et al[18] found smoking and younger patient age were indicators of poor compliance in HD and peritoneal dialysis. Other studies have analyzed the obstacles preventing adherence to dialysis regimens, including attending HD sessions, taking medications, and following the recommended diet.[19-22]

Our study is the first, to our knowledge, to assess patient compliance in the AVF maturation period. Compliance with AVF follow-up is an important aspect of timely maturation to enable early recognition of stenosis or thrombosis and to facilitate proper permission to cannulate.[17] Because permission to use the AVF is given by the vascular surgeon in our community, our goal in establishing a standard follow-up schedule was to place patients into the algorithm of "okay to use AVF," "needs intervention to mature," or "needs to be abandoned and new access creation" sooner, which requires patient compliance with the follow-up schedule.

As the literature suggests, our hypothesis was that improving patient follow-up compliance would improve time to cannulation; however, as our report states, the QI initiative was unable to improve patient compliance. Thus, we cannot really investigate the effect that the implementation of the protocol had on AVF outcomes. Because the QI initiative did not affect our poor patient compliance, the protocol could not have had any effect on the time to cannulation because a prerequisite of time to cannulation is to have a follow-up visit to get permission to cannulate.

Although the QI significantly increased the percentage of patients who followed up within 30 days of AVF creation from 48% to 65%, the trend did not continue with a fistulogram within 40 days or second appointment in 55 days. Because most approvals to cannulate come at the second appointment or later, this failure to enforce timely follow-up >30 days limited the effect of the QI, resulting in no significant improvement in patient outcomes. Without meeting our primary goal of facilitating patient adherence to the follow-up protocol, assessing whether designating and facilitating patient follow-up can affect AVF time to maturation or failure is difficult. In fact, the intervention rate in the QI cohort was higher than in the pre-QI cohort, meaning overall there was an increase in intervention and cost without a resulting improvement in AVF usage.

One important point to note is the demographic and socioeconomic distribution of our target population. Compared with nationwide ESRD network data, our patient cohorts had a similar percentage of male patients; however, our percentage of patients who were African American, diabetic, and uninsured was the same or higher than any of the networks and far higher than in Europe or Japan.[4,23] Furthermore, African American patients have the lowest rates of pre-ESRD nephrologist care, which is associated with higher percentages of patients initiating dialysis via a catheter[5] and with poorer fistula outcomes compared with other races.[24-26]

In our study, the overall compliance with the first follow-up appointment within 30 days in the African-American patient population was 55% at an average of 37 days from access creation, whereas compliance in the Caucasian patient population was 66% ($P = .230$) at an average of 31 days from access creation ($P = .100$). Compliance with the second follow-up appointment was 22% at an average of 80 days from access creation in the African American patient population and 37% ($P = .101$) at an average of 66 days from access creation ($P = .001$) in Caucasian patients. Overall time to permission to cannulate was 89 days with a failure to mature rate of 22% in the African American patient population, whereas time to permission was 88 days ($P = .880$) with a failure rate of 21% ($P = .809$) in the Caucasian patient population. The African American and Caucasian cohorts were both 43% female, whereas the overall mean age was 58 years for African American patients vs 66 years for Caucasian patients ($P = .002$), and 70% vs 67% were already on HD at the time of access creation ($P = .648$).

ESRD networks with high-risk patient populations like ours are especially motivated to implement KDOQI and FFBI recommendations to improve their HD access outcomes, but evidence of significant improvement with use of these techniques is scarce. The KDOQI exhorts implementation of multidisciplinary teams, integrating early referral, best clinical practices, patient education, and surveillance to provide the best and safest HD access to patients. Logically, earlier referrals from nephrologists should increase the percentage of patients initiating HD with an AVF. Earlier referral is also expected to decrease the number of patients already on HD who present to vascular surgeons for an initial assessment, which was disconcertingly high in our cohorts (68% in the pre-QI and 66% in the QI cohort). However, some recent studies have shown this may not translate into appreciable benefits in randomized controlled trials.[9]

Other groups have developed risk equations to predict successful maturation or failure, with little ability to translate these equations into clinical use.[24,27] Several studies defend the placement of AVFs in elderly, diabetic, or female patients,[28-30] whereas some groups contend an AVG may be a valid alternative if it avoids long-term use of TDCs.[31,32] Even surveillance and monitoring tools have not led to significant benefits.[16,17] Overall, experts agree the evidence influencing clinical practice of HD access placement and maintenance is of very low quality. This leaves practices trying different strategies and independently assessing the effect the change has in their respective populations.

Limitations of our study include its retrospective nature, the small number of patients in each cohort, the significant number of patients who were lost to follow-up, and the limited follow-up period of 6 months for the

QI cohort. In addition, we did not assess patient factors that caused the poor compliance, such as transportation, inability to afford copay, and comorbid illness, among others. Future studies should analyze these factors contributing to noncompliance that were anecdotally discussed with our patient liaison, which may yield suggestions to improve compliance.

Our results suggest two possible areas of improvement for AVF patient outcomes. First, the high proportion of patients undergoing initial HD access creation who were already receiving HD through a catheter is a significant concern to our group. Although studies present conflicting data on the possible benefits of early access creation, it is worth attempting to start these patients in access proceedings earlier to realize the possible improvement of time to permission to cannulate and failure rate.[31,32] Catheter use before AVF placement is associated with a higher rate of AVF failure,[23] which means most of our patient population was already at a disadvantage in terms of AVF maturation at the time of access creation. Hence, starting the proceedings early is another AVF maturation factor left to improve in our population to realize better outcomes for our patients. This involves not only earlier referrals from nephrologists but also earlier patient presentation to nephrologists, which may not be within our power to influence without large-scale patient education.

Second, reflecting on input our patient liaison has received from patients and the difficulty with enforcing patient follow-up at our clinic, we believe our surveillance protocol needs to be re-evaluated to suit our patients, who are dealing with dialysis appointments, cost of office visits if not yet on Medicare, transportation problems, or comorbid health concerns. In addition, although Medicare, Medicaid, and other insurers have reimbursed all fistula maturation duplex ultrasound assessments in our group, future legislation and reimbursement guidelines may preclude this practice. Integrating follow-up surveillance with nephrologist or dialysis appointments to monitor AVF maturation has the potential to make follow-up more patient-centered, cost-effective, and hopefully, improve patient compliance.

CONCLUSIONS

By instituting a QI initiative including a standardized protocol and patient liaison, we hoped to decrease AVF time to maturation and failure to mature rates. The QI initiative significantly increased the number of patients complying with the first 30-day follow-up appointment after access creation. Despite this initial success, patient compliance with a timely fistulogram and the second follow-up appointment was very poor and not influenced by the QI initiative, thus limiting the functional effect of the QI initiative on time to AVF maturation. Improving AVF outcomes and use to the levels set by FFBI in our population may necessitate a more integrated QI program, including earlier referrals from nephrologists, failure to mature deadlines, patient and community education, and communication with dialysis units.

AUTHOR CONTRIBUTIONS

Conception and design: SL, SA, JP
Analysis and interpretation: SL
Data collection: SL
Writing the article: SL
Critical revision of the article: SA, JP, MG
Final approval of the article: SA, JP
Statistical analysis: SL, DD
Obtained funding: JP
Overall responsibility: SL

REFERENCES

1. National Kidney Foundation. KDOQI Clinical Practice Guidelines and Clinical Practice Recommendations for 2006 Updates: hemodialysis adequacy, peritoneal dialysis adequacy and vascular access. Am J Kidney Dis 2006;48(Suppl 1):S1-322.
2. Leermakers JJ, Bode AS, Vaidya A, van der Sande FM, Evers SM, Tordoir JH. Cost-effectiveness of vascular access for haemodialysis: arteriovenous fistulas versus arteriovenous grafts. Eur J Vasc Endovasc Surg 2013;45:84-92.
3. Mid-Atlantic Renal Coalition. 2010 Fistula First Breakthrough Initiative annual report. Lake Success, NY: IPRO ESRD Network of New York; 2011. Available at: http://www.fistulafirst.org. Accessed February 27, 2014.
4. U.S. Renal Data System, USRDS 2013 Annual Data Report: atlas of chronic kidney disease and end-stage renal disease in the United States. Bethesda, MD: National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases; 2013.
5. Murad MH, Elamin MB, Sidawy AN, Malaga G, Rizvi AZ, Flynn DN, et al. Autogenous versus prosthetic vascular access for hemodialysis: a systematic review and meta-analysis. J Vasc Surg 2008;48:34-47S.
6. Sidawy AN, Spergel LM, Besarab A, Allon M, Jennings WC, Padberg FT, et al. The Society for Vascular Surgery: clinical practice guidelines for the surgical placement and maintenance or arteriovenous hemodialysis access. J Vasc Surg 2008;48(5 Suppl):2-25S.
7. Biuckians A, Scott EC, Meier GH, Panneton JM, Glickman MH. The natural history of autologous fistulas as first-time dialysis access in the KDOQI era. J Vasc Surg 2008;47:415-21.
8. Asif A, Prabir R-C, Beathard GA. Early arteriovenous fistula failure: a logical proposal for when and how to intervene. Clin J Am Soc Nephrol 2006;1:332-9.
9. Asif A, Leon C, Orozco-Vargas LC, Krishnamurthy G, Choi KL, Mercado C, et al. Accuracy of physical examination in the detection of arteriovenous fistula stenosis. Clin J Am Soc Nephrol 2007;2:1191-4.
10. Beathard GA. An algorithm for the physical examination of early fistula failure. Semin Dial 2005;18:331-5.
11. Leon C, Asif A. Physical examination of arteriovenous fistulae by a renal fellow: does it compare favorably to an experienced interventionalist? Semin Dial 2008;21:557-60.
12. Robbin ML, Chamberlain NE, Lockhart ME, Gallichio MH, Young CJ, Deierhoi MH, et al. Hemodialysis arteriovenous fistula maturity: US evaluation. Radiology 2002;225:59-64.
13. Tessitore N, Bedogna V, Poli A, Mantovani W, Lipari G, Baggio E, et al. Adding access blood flow surveillance to clinical monitoring reduces thrombosis rates and costs, and improves fistula patency in the short term: a controlled cohort study. Nephrol Dial Transplant 2008;23:3578-85.
14. Murad MH, Sidawy AN, Elamin MB, Rizvi AZ, Flynn DN, McCausland FR, et al. Timing of referral for vascular access placement: a systematic review. J Vasc Surg 2008;48(5 Suppl):31-33S.
15. Kimball TA, Barz K, Dimond KR, Edwards JM, Nehler MR. Efficiency of the kidney disease outcomes quality initiative guideline for preemptive vascular access in an academic setting. J Vasc Surg 2011;54:760-6.
16. Kleinpeter MA, Duval L, Hedrick N, Woodruff S. An arteriovenous fistula (AVF) functionality quality improvement tracking tool—developed

and implemented to improve newly placed AVF utilization rates and patient outcomes. Nephrol Nurs J 2010;37:655-62.
17. Riella MC, Roy-Chaudhury P. Vascular access in haemodialysis: strengthening the Achilles' heel. Nat Rev Nephrol 2013;9:348-57.
18. Kutner NG, Zhang R, McClellan WM, Cole SA. Psychosocial predictors of non-compliance in haemodialysis and peritoneal dialysis patients. Nephrol Dial Transplant 2002;17:93-9.
19. Griva K, Lai AY, Lim HA, Yu Z, Foo MWY, Newman SP. Non-adherence in patients on peritoneal dialysis: a systematic review. PLoS One 2014;9:e89001.
20. Loghman-Adham M. Medication noncompliance in patients with chronic disease: issues in dialysis and renal transplantation. Am J Manag Care 2003;9:155-71.
21. Kammerer J, Garry G, Hartigan M, Carter B, Erlich L. Adherence in patients on dialysis: strategies for success. Nephrol Nurs J 2007;34:479-86.
22. Chan YM, Zalilah MS, Hii SZ. Determinants of compliance behaviours among patients undergoing hemodialysis in Malaysia. PLoS One 2012;7:e41362.
23. Asano M, Thumma J, Oguchi K, Pisoni RL, Akizawa T, Akiba T, et al. Vascular access care and treatment practices associated with outcomes of arteriovenous fistula: international comparisons from the Dialysis Outcomes and Practice Patterns Study. Nephron Clin Pract 2013;124:23-30.
24. Lok CE, Allon M, Moist L, Oliver MJ, Shah H, Zimmerman D. Risk equation determining unsuccessful cannulation events and failure to maturation in arteriovenous fistulas (REDUCE FTM I). J Am Soc Nephrol 2006;17:3204-12.
25. Allon M, Robbin ML. Increasing arteriovenous fistulas in hemodialysis patients: problems and solutions. Kidney Int 2002;62:1109-24.
26. Hod T, DeSilva RN, Patibandla BK, Vin Y, Brown RS, Goldfarb-Rumyantzev AS. Factors predicting failure of AV "fistula first" policy in the elderly. Hemodial Int 2013;28:507-15.
27. Lilly MP, Lynch JR, Wish JB, Huff ED, Chen CS, Armistead NC, et al. Prevalence of arteriovenous fistulas in incident hemodialysis patients: correlation with patient factors that may be associated with maturation failure. Am J Kidney Dis 2012;54:541-9.
28. Rajan DK, Bunston S, Misra S, Pinto R, Lok CE. Dysfunctional autogenous hemodialysis fistulas after angioplasty—are there clinical predictors of patency? Radiology 2004;232:508-15.
29. Smith GE, Gohil R, Chetter IC. Factors affecting the patency of arteriovenous fistulas for dialysis access. J Vasc Surg 2012;55:849-55.
30. Swindlehurst N, Swindlehurst A, Lumgair H, Mesa IR, Mamode N, Cacciola R, et al. Vascular access for hemodialysis in the elderly. J Vasc Surg 2011;53:1039-43.
31. Disbrow DE, Cull DL, Carsten CG, Yang SK, Johnson BL, Keahey GP. Comparison of arteriovenous fistulas and arteriovenous grafts in patients with favorable vascular anatomy and equivalent access to health care: is a reappraisal of the Fistula First Initiative Indicated? J Am Coll Surg 2013;216:679-85.
32. Casey ET, Murad MH, Rizvi AZ, Sidawy AN, McGrath MM, Elamin MB, et al. Surveillance of arteriovenous hemodialysis access: a systematic review and meta-analysis. J Vasc Surg 2008;48(5 Suppl):48-54S.

Submitted Apr 14, 2014; accepted May 30, 2014.